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Vol. II
Part I
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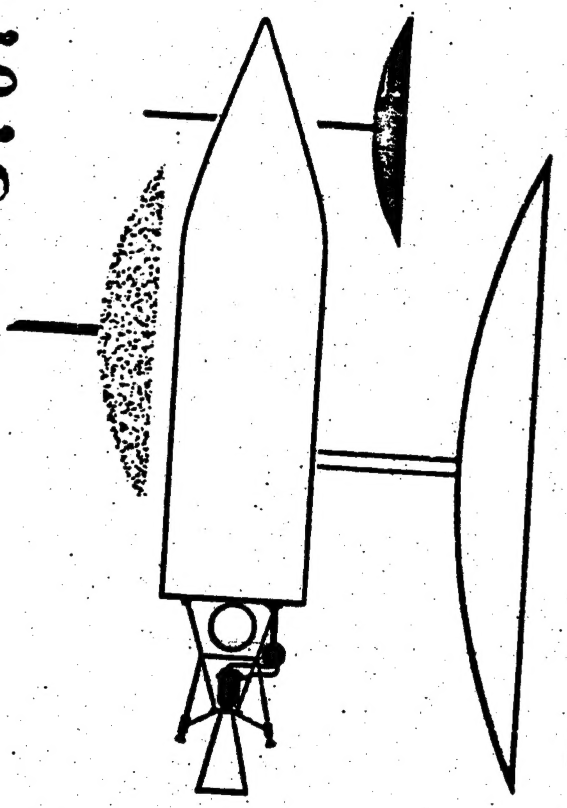

Pied Piper
DEVELOPMENT PLAN

VOL. II SUB-SYSTEM PLAN

I. Airborne Test Systems

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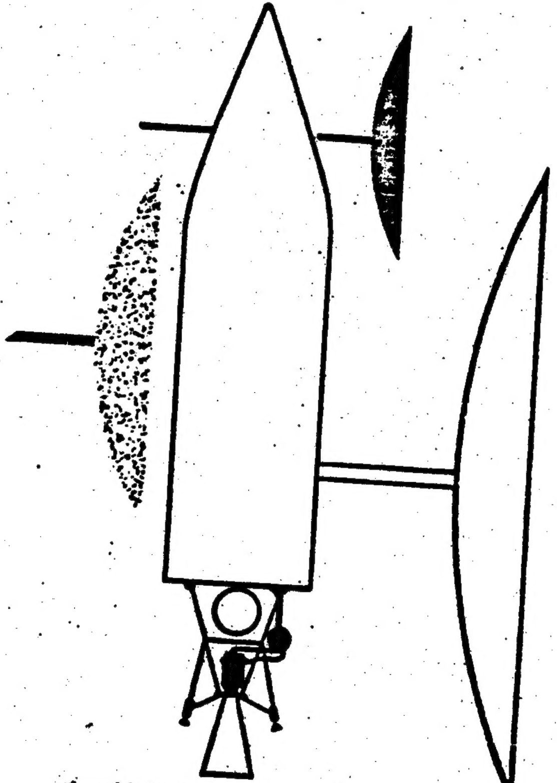

Pied Piper DEVELOPMENT PLAN

VOL. II SUB-SYSTEM PLAN

I. Airborne Test Systems

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FOREWORD

The Advanced Reconnaissance System (ARS) consists of a satellite vehicle containing equipment to perform visual, ferret, and infrared reconnaissance, together with the necessary system of ground stations and data processing centers.

This Development Plan for the accomplishment of the ARS was prepared by the Missile Systems Division, Lockheed Aircraft Corporation and its subcontractors, CBS Laboratories and Eastman Kodak Company. The specifications for the system were determined in the course of a one-year study now being conducted for the United States Air Force under contract AF 33(616)-3105. The plan is presented in two parts; Volume I, System Plan, and Volume II, Subsystem Plan. The subsystems are described in separate books, Volume II-A through II-L.

PIED PIPER DEVELOPMENT PLAN

VOLUME I. SYSTEM PLAN

VOLUME II. SUBSYSTEM PLAN

A. Airframe
B. Propulsion
C. Auxiliary Power
D. Guidance and Control
E. Visual Reconnaissance
F. Electronic Reconnaissance
G. Infrared Reconnaissance
H. Vehicle Electronics
I. Airborne Test Systems
J. Vehicle Intercept and Control Ground Station
K. Ground Data Processing
L. Vehicle Ground Support

CONTENTS

Subsystem I Airborne Test Systems

RDB PROJECT CARD (Form DD 613)
- Tab 1 General Design Specifications
- Tab 2 Subsystem Summaries
  - Milestones
  - Hardware Delivery
  - Test Schedules
  - R and D Schedules
- Tab 3 R and D Tests (Form ARDC 105)
- Tab 4 R and D Test Aircraft (Form ARDC 106)
- Tab 5 R and D Materiel (Form (ARDC 107)
- Tab 6 Required Facilities
- Tab 7 R and D Contract Funds
- Tab 8 Estimate of Manpower Requirements

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MSD 1536

RDB PROJECT CARD

TYPE OF REPORT
New Subsystem Development Plan

REPORTS CONTROL SYMBOL
DD-RDB(A)48

1. PROJECT TITLE
AIRBORNE TEST SUBSYSTEM FOR ADVANCED RECONNAISSANCE SYSTEM (Unclassified)

(Pied Piper)

2. SECURITY
Secret

3. PROJECT NUMBER
1115

4. INDEX NUMBER

5. REPORT DATE
1 March 1956

6. BASIC FIELD OR SUBJECT

7. SUBFIELD OR SUBJECT SUBGROUP

7A. TECH. OBJ.

8. COGNIZANT AGENCY

9. DIRECTING AGENCY

OFFICE SYMBOL

TELEPHONE NO.

10. REQUESTING AGENCY

11. PARTICIPATION, COORDINATION, INTEREST

12. CONTRACTOR AND/OR LABORATORY
Lockheed Aircraft Corp.
Missile Systems Division

CONTRACT/W.O. NO.
AF 33(616)-3105

13. RELATED PROJECTS

14. DATE APPROVED

15. PRIORITY
Maximum

16.

17. EST. COMPL. DATES

RES.	
DEV.	
TEST	
OP. EVAL.	

18. FY	FISCAL ESTS. (M $)

19.

20. REQUIREMENT AND/OR JUSTIFICATION

a. This subsystem provides vehicles and airborne equipment and instrumentation for development flight testing of the Advanced Reconnaissance System.

b. Performance characteristics of reconnaissance and geophysical measurement devices will be evaluated under orbital conditions in free space.

c. Operational techniques associated with the preparation, launching, tracking, and data transmission of a satellite will be evaluated.

22. RDB

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MISSILE SYSTEMS DIVISION

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R&D PROJECT CARD
CONTINUATION SHEET

SECURITY CLASSIFICATION
SECRET

1. PROJECT TITLE AIRBORNE TEST SUBSYSTEM FOR ADVANCED RECONNAISSANCE SYSTEM (Unclassified) (Pied Piper)	2. SECURITY OF PROJECT Secret	3. PROJECT NUMBER 1115
	4.	5. REPORT DATE 1 March 1956

51 yrs old + Garbage

21 a. ~~Brief and Operational Characteristics~~

~~The subsystem consists of airborne test instrumentation and four types of vehicles which are to be used in development flight testing of airframes, payload (reconnaissance) equipment, and information sensing and transmission equipment. Environmental data and operational characteristics of range of elements from isolated items through complete subsystems will be provided. Ballistic and orbiting flight tests are scheduled. Instrumentation and test vehicles have been selected to utilize state-of-art components in the initial phases. Their flight test performance is to be adequate for the required data, and they have been scheduled to provide design and development information when required in the over-all system development plan.~~

Release

21 b. Approach

Information concerning vehicle environment and dynamics and component operation is required. This subsystem is designed to supply a major part of this information through flight testing. Four basic vehicle types will be used, each of which has as its purpose the provision of an airborne vehicle for the evaluation of specific problem areas:

(1) Vehicle components and functions are tested in the System Test Vehicle (STV), a non-orbiting vehicle of limited range and flight duration;

(2) Full-scale airframe systems are functionally tested in captive firings of the orbit stage test vehicles (OSTV);

(3) Satellite systems are evaluated in long-range ballistic flight tests in the non-orbiting test vehicle (NOTV);

(4) Operational techniques and problems of satellite flight are evaluated with Orbiting Test Vehicles (OTV).

Major problem areas are expected to be principally those associated with the unknown environmental factors, namely the unattended operation of equipment for sustained periods of flight and the acquisition and transmission of test information in orbit at 300 n. miles. Targets in the development plan are successful staging from the booster, air-starting and cutoff of the propulsion units, and the placing of a test vehicle in orbit in CY 1958.

21 c. Subsystem Tasks

1.a Test Instrumentation (Airborne)

b Contractors: Lockheed Aircraft Corporation - Missile Systems

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CONTINUATION SHEET

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1. PROJECT TITLE AIRBORNE TEST SUBSYSTEM FOR ADVANCED RECONNAISSANCE SYSTEM (Unclassified) (Pied Piper)	2. SECURITY OF PROJECT Secret	3. PROJECT NUMBER 1115
	4.	5. REPORT DATE 1 March 1956

21 c Division; CBS Laboratories; Eastman Kodak Company.

c A PWM/FM telemeter of approximately 15 channels will be used for transmission of flight test data. On early flights, measurements will consist of system performance parameters, environmental data for design information, and geophysical data affecting flights and equipment. Later flights will require instrumentation of payload systems to evaluate this operation in the satellite environment. Geophysical data such as meteor impact, radiation and atmospheric characteristics will be obtained in the orbiting vehicles.

2.a Systems Test Vehicle

b Contractor: Lockheed Aircraft Corporation - Missile Systems Div.

c The Systems Test Vehicle (STV) consists of a one-half scale airframe which weighs up to 1600 pounds gross weight and is boosted by a T-34 (Sergeant) rocket. This booster is essentially that used for the X-17 Re-entry Test Vehicle, with minor modifications to the fins and stage interconnect structure. Forty-three vehicles will be used for the evaluation of flight environment and for testing telemeter and vehicle electronics equipment, orbit stage propulsion system, battery and chemical auxiliary power units, guidance and control components and system, and components of the reconnaissance payloads. These vehicles are non-orbiting, but they permit approximately eight minutes of flight above 300 n. miles altitude when orbit stage propulsion is operative.

3.a Orbit Stage Test Vehicle

b Contractor: Lockheed Aircraft Corporation - Missile Systems Div.

c Two captive firings of the Orbit Stage Test Vehicle (OSTV) will be conducted. These are functional tests of the major vehicle subsystems. They will demonstrate proper operation of the propulsion units and their fuel supply and control systems. Environmental effects of operating engines on other equipment will also be evaluated.

4.a Non-Orbiting Test Vehicles

b Contractor: Lockheed Aircraft Corporation - Missile Systems Division

DD FORM 613-1 5 FEB 53 PREVIOUS EDITIONS OF THIS FORM MAY BE USED

SECURITY CLASSIFICATION SECRET

R&D PROJECT CARD
CONTINUATION SHEET

SECRET
SECURITY CLASSIFICATION

1. PROJECT TITLE	2. SECURITY OF PROJECT	3. PROJECT NUMBER
AIRBORNE TEST SUBSYSTEM FOR ADVANCED RECONNAISSANCE SYSTEM (Unclassified) (Pied Piper)	Secret	1115
	4.	5. REPORT DATE 1 March 1956

21 c

c Full-scale non-orbiting flight tests (NOTV) will be conducted with the combined systems that have been proved satisfactory in the STV series of tests. Three NOTV tests are scheduled and will provide performance characteristics of essentially complete satellite vehicle systems. These vehicles will be boosted by Atlas "C" boosters, and they will demonstrate guidance and control characteristics of the booster-vehicle combination, separation, air starting of satellite stage propulsion and APU units, and vehicle transition trajectory data.

5.a Orbiting Test Vehicles

b Contractor: Lockheed Aircraft Corporation - Missile Systems Div.

c Six orbiting tests are planned as final demonstration of the system capability and will investigate the problems associated with the placing of a payload in orbit. Primary emphasis in these flights will be placed in providing as much instrumentation as is required to evaluate proper operation and accuracy, as well as the useful life of attitude controls, the programmer, sensing and telemetry equipment, and reconnaissance components. Data on orbital environment, such as meteorites, drag and cosmic radiation, will also be obtained. An additional series of 15 orbiting vehicles, designated Payload Test Vehicles (PTV), are also planned. Although used primarily for the testing of complete reconnaissance, ferret, and nuclear APU systems, they are identical in configuration to the operational satellite.

21 d Other Information

1. General. The purpose of this subsystem is to provide flight test data required for reconnaissance system development. A description of the configuration and performance is contained in the General Design Specification.

2. Survey of Similar Existing Standardized Equipment. All known available items have been used wherever their performance characteristics are compatible with the subsystem requirements and over-all system development plan. X-17 booster motor and airframe are employed for one-half scale tests; Vanguard second-stage propulsion units are also used. Early instrumentation systems are similar to that used in the X-17 project. Standardized hardware and accessories are used wherever appropriate.

R&D PROJECT CARD
CONTINUATION SHEET

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1. PROJECT TITLE	2. SECURITY OF PROJECT	3. PROJECT NUMBER
AIRBORNE TEST SUBSYSTEM FOR ADVANCED RECONNAISSANCE SYSTEM (Unclassified) (Pied Piper)	Secret	1115
	4.	5. REPORT DATE 1 March 1956

21 d

3. Similar Equipment in Process of R & D. This subsystem consists of flight test items for the Advanced Reconnaissance System, and does not duplicate any equipment in the process of R & D.

4. Replacement Recommendations. This subsystem is for test purposes only and will not replace any known existing equipment.

5. Statement of Effects. This subsystem will be maintained and operated by contractor personnel. Facilities for flight test operation and range instrumentation will be required at AFMTC.

21 e Background History

This subsystem is a result of work conducted under contract AF 33(616)-3105. The requirement for this subsystem is described in Pied Piper Progress Reports (see references).

21 f Future Plans

Development of this subsystem is contingent upon provisions of boosters for STV, NOTV, and OTV series. Flight test schedules may be revised to satisfy data requirements by re-assigning objectives and instrumentation.

f References

Lockheed Missile Systems Division Report MSD 1363, Pied Piper - First Quarterly Progress Report, Vol. IV, 1 November 1955 (S)

Lockheed Missile Systems Division Report MSD 1481, Pied Piper - Second Quarterly Progress Report, 15 January 1956 (S)

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MISSILE SYSTEMS DIVISION

TABS

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Subsystem I - AIRBORNE TEST SUBSYSTEM

Tab 1 - General Design Specifications

I. GENERAL

A. Statement of the Problem

It is required that information be obtained to evaluate the environment in which the satellite vehicle will be operating. The flight dynamics of the system and the general performance characteristics of the equipment and payload subsystems to obtain this information will require that a flight test program be conducted concurrent with the research and engineering analyses, so that the operational equipment can be placed in an environment as similar as possible to that which will exist in orbit.

B. Approach

A flight test program has been devised to provide answers to the problems described above. These problem areas define the performance characteristics which will be required of the vehicles. Flight loads, such as accelerations and vibrations will be attained which will correspond more closely to the operational environment than laboratory testing permits. Aerodynamic heating and structural problems will be evaluated. Environmental effects such as drag, cosmic radiations, meteors, and temperature control will be investigated in the orbiting test vehicles. To accomplish these objectives sustained flight at high altitude is an ultimate requirement. A preliminary evaluation of these effects can be obtained, however, by vehicles which obtain a high apogee ballistic trajectory even with limited range. Such a partial solution imposes less strenuous requirements on test range launching facilities and instrumentation. In the latter phases of the program, orbiting vehicles are planned which will result in a vehicle configuration thoroughly demonstrating the operational characteristics required.

C. Solution

To implement the flight test program as rapidly as possible, existing components have been surveyed to determine their possible utility in early flight tests. An available solid propellant rocket booster, the T-34 (Sergeant) will be used for ballistic testing at approximately 1/2 scale. This vehicle will accommodate full scale components of the ultimate payload. Airborne test instrumentation will be used which is currently available; it will be similar to the instrumentation of the X-17 Re-entry Test Vehicle. Components of reconnaissance payload, optical equipment and electronic data link equipment, may be tested early in the flight program to determine the performance characteristics of these isolated units.

Flight testing will continue to provide the earliest feasible sources of information, and the objectives of each test are established to provide information inputs in the overall system development program, as they are most urgently needed. In this manner, the earliest possible freezing of the design and characteristics of operational equipment can be obtained. Further, through orbiting test vehicles, information of general interest, such as geophysical measurements, will be forthcoming, and the performance and reliability of more or less complete payload subsystems may be evaluated.

II. DESCRIPTION

The following test vehicles have been selected to satisfy the requirements outlined in the preceeding paragraphs. The flight test program will proceed from 1/2 scale ballistic vehicles, through test orbiting airframes which are fired on ballistic trajectories, to the final airframe which is almost identical to that of the first operational vehicles. A full range of payload equipment can be flight tested, and the number of tests of each vehicle type has been established to provide all flight operational data which will be required.

Task 1 - Airborne Test Instrumentation

For the gathering of information during flight test, equipment will be provided to measure accelerations, vibrations, pressures, and temperatures. Strain gages will be applied for structural measurements. Tell-tales will monitor operations such as stage unlatching and separation. Payload equipment will be instrumented to obtain data on component functioning and failure analysis, should malfunction occur.

In addition, orbiting vehicles will be instrumented to obtain indications of meteor impact (by microphones and pressure gages), drag, cosmic radiation and geophysical information as described in the appendix to this volume.

Task 2 - Systems Test Vehicle

The Systems Test Vehicle (STV) will consist of an airframe of 31-in. diameter and approximately 45 feet long including its booster and is very nearly one half the size of the operational vehicle. It will be as similar in configuration (nose shape and equipment location) as is permitted by the testing of full scale components in a reduced scale vehicle and will weigh up to 1600 lbs. with its full payload capacity. It will be boosted by a T-34 rocket. The booster airframe is essentially that which is used for the X-17 Re-entry Test Vehicle, except that minor modification may be required to the fins for aerodynamic stability, and to the stage interconnect structure to accommodate a nose which is of the same diameter as the rocket. A typical configuration of the STV is shown in the appendix. This vehicle will carry, in later flights, a full scale vehicle sustainer engine with a limited quantity of fuel and two control engines as used in the full scale vehicle for attitude and transition trajectory control. Forty-one of these vehicles will be flight tested.

The typical performance of the STV without sustainer engine operation results in apogee and range of 150 and 800 miles respectively, for a flight duration of 6 minutes above 100,000 feet, and for a total flight duration of 8 minutes. With sustainer engine operating, trajectories will [illegible] tained which result in flight above 300 miles for 8 minutes. It [illegible] lent that flights of considerable duration at extremely high altitude ([illegible] 300 miles) will provide much data on the operational characteristics in vacuo of the equipment being tested.

Task 3 - Orbital Stage Test Vehicle

The Orbital Stage Test Vehicle (OSTV) is a full scale vehicle airframe which will be used for captive flight test. Such firings will be performed to provide a functional test of several major test vehicle subsystems. Principally, they will demonstrate the proper operation of the propulsion subsystem units, the fuel supply and control equipment, and engine starting and cut off techniques. In addition, they will allow an evaluation of the operational characteristics of payload and vehicle electronic components in the environment attendant on engine operation, such as vibration, acceleration, and local temperatures during engine burning.

Task 4 - Non Orbital Test Vehicles

Full scale non-orbital test vehicles (NOTV) flight tests will be conducted of combined subsystems that have been proven out in the STV series. Three of these tests are scheduled. They will be boosted by the XSM-65C.

The configuration of the NOTV, shown in the appendix, will contain items of payload equipment which have been advanced in their development to a quasi-operational level. This vehicle is 61 in. in diameter and 216 in. long and will weigh 3500 pounds. A typical flight of the NOTV will be a ballistic trajectory with apogee of over 600 miles and 1,000 miles total range. Significantly more information will be obtained from these flight tests concerning general system parameters and equipment performance and reliability, since the effective flight duration is about 15 minutes.

Task 5 - Orbital Test Vehicle

The Orbital Test Vehicle(OTV) is essentially an operational satellite vehicle, except that it will not contain complete subsystems for obtaining reconnaissance information. It may be flight tested either at AFMTC or the proposed ultimate launching site. These vehicles will be placed originally on east-west orbits which will not provide information of strategic reconnaissance interest, but which can be better implemented with ground control facilities. A typical OTV configuration is shown in the appendix to subsystem A. These vehicles will be boosted by the XSM-65C and will be able to carry up to 1600 lbs. of payload equipment depending on booster performance. The OTV flight test will have orbiting durations ranging from 5 days to 10 days, depending upon the type of auxiliary power subsystem supplied. A total of 6 flight tests is planned.

An additional series of fifteen orbiting vehicles, designated Payload Test Vehicle (PTV), are also planned. They are configurationally identical to the operational satellite (see appendix) though used primarily for the testing of complete reconnaissance, ferret and nuclear APU subsystems. These vehicles will utilize the advanced propulsion subsystem. They may be launched either from AFMTC or the ultimate site.

~~Subsystem I - AIRBORNE TEST~~

Tab 2 Summary - Subsystem Milestones

Complete Design for First STV

Delivery of First STV to AFMTC

Delivery of First STV with Second Stage Propulsion to AFMTC

Delivery of First OSTV for Captive Test LAC STF

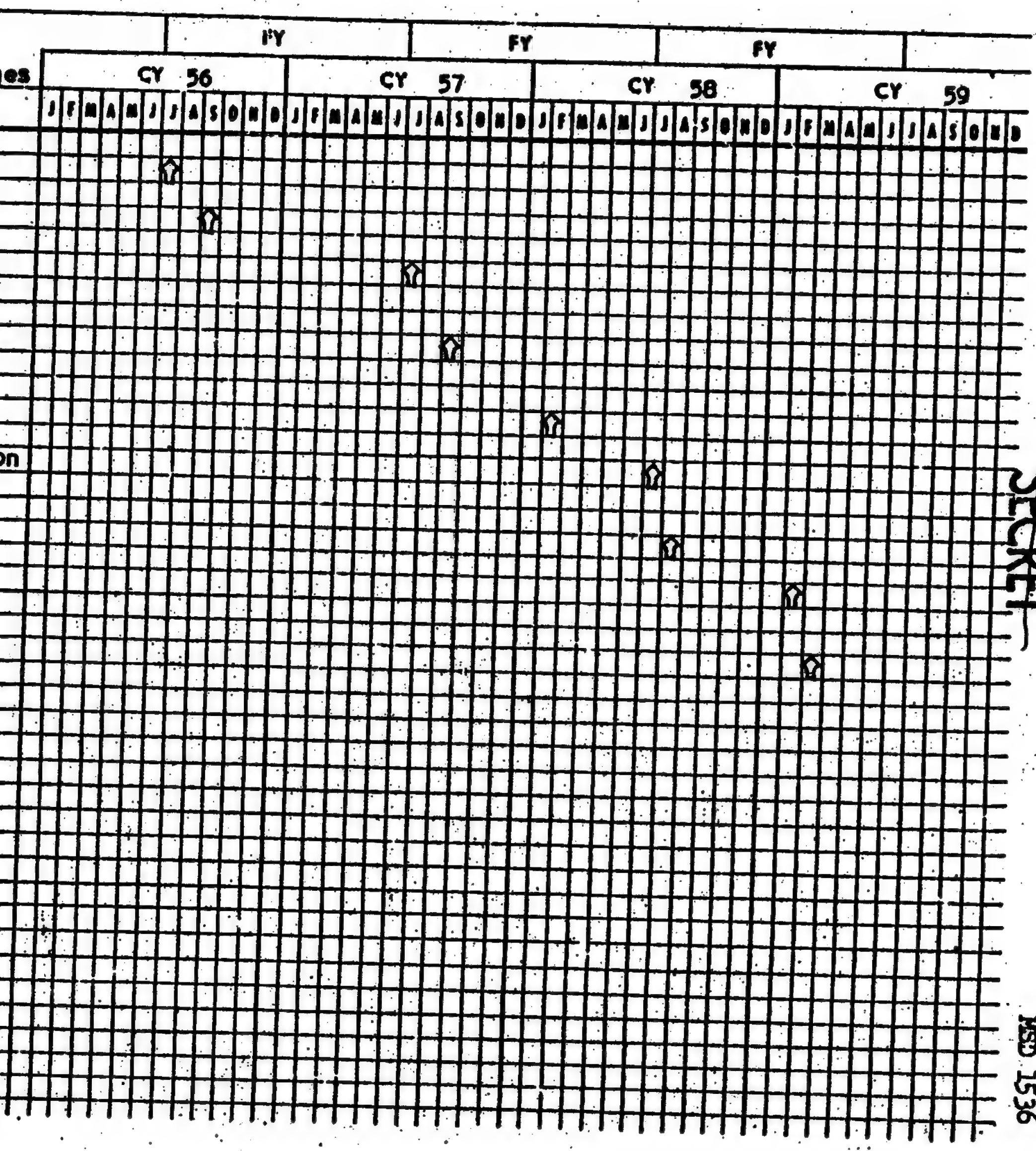
Delivery of First NOTV to AFMTC

Delivery of First OTV Instrumentation Package

Delivery of First OTV to AFMTC

Delivery of First PTV with Ferret Payload to AFMTC

Delivery of First PTV with Visual Recon. Payload to AFMTC



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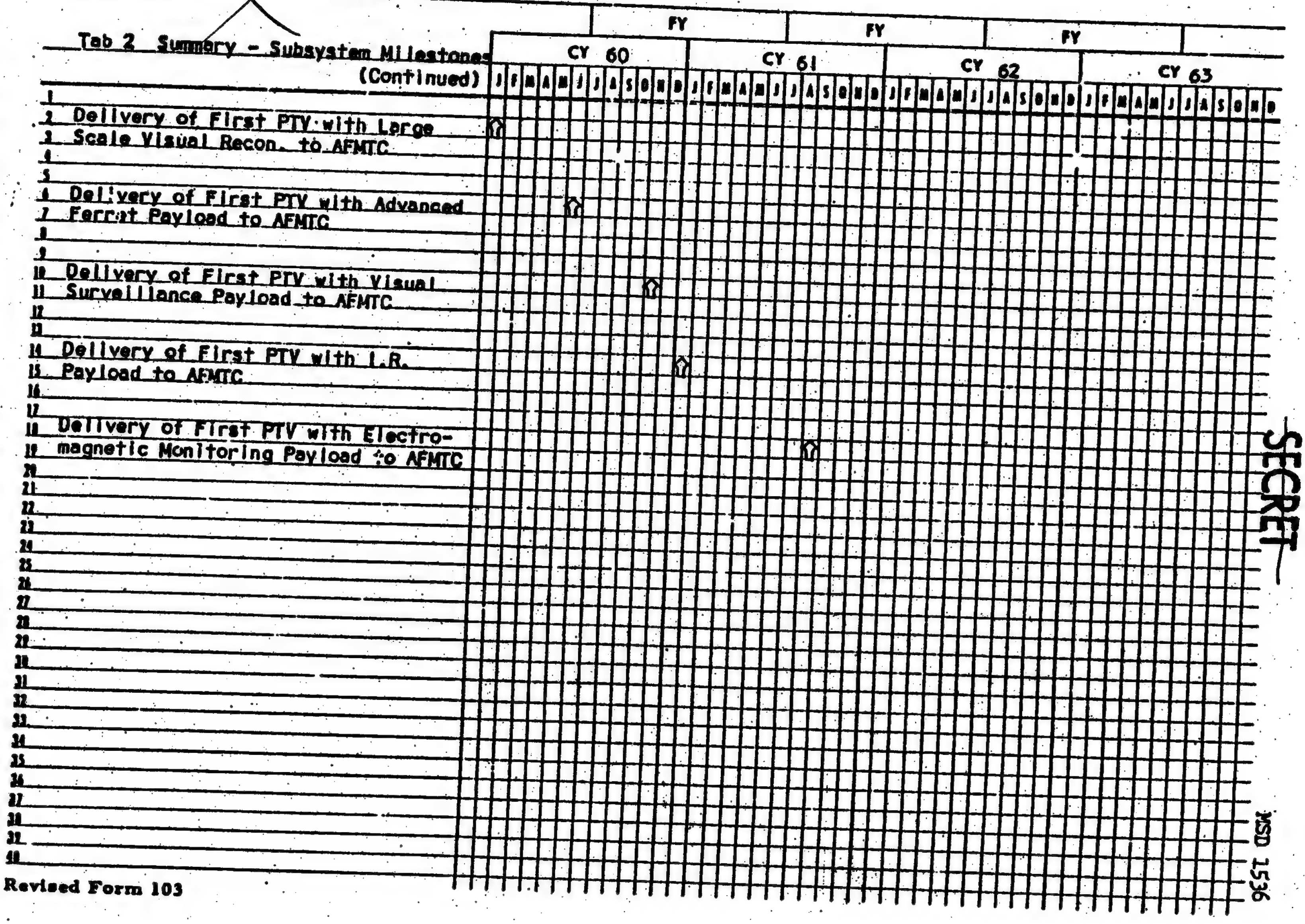
Subsystem I - ~~AIRBORNE~~ TEST

Tab 2 Summary - Subsystem Milestones (Continued)



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MISSILE SYSTEMS DIVISION

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LOCKHEED AIRCRAFT CORPORATION

Subsystem I - AIRBORNE TEST

Tab 2 Summary - Hardware Delivery

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	CY 56											
	J	F	M	A	M	J	J	A	S	O	N	D
I - Airborne Test Instrumentation								1	1	1	1	1
II - Systems Test Vehicles									1	1	1	1
III - Orbit Stage Test Vehicles												
IV - Non-orbit Test Vehicles												
V - Orbit Test Vehicles QTV & PTV												

							FY					
	CY 57											
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III - Orbit Stage Test Vehicles							1	1				
IV - Non-orbit Test Vehicles												
V - Orbit Test Vehicles QTV & PTV												

							FY					
	CY 58											
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II - Systems Test Vehicles	1	1	1	1	1	1	1	1			1	
III - Orbit Stage Test Vehicles												
IV - Non-orbit Test Vehicles		1		1		1						
V - Orbit Test Vehicles QTV & PTV									1	1	1	

	CY 59											
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I - Airborne Test Instrumentation	1	1	1	1	2	1	2	2	2	2	1	2
II - Systems Test Vehicles	1				1		1		1			1
III - Orbit Stage Test Vehicles												
IV - Non-orbit Test Vehicles												
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Subsystem I - ~~AIRBORNE~~ TEST

Tab 2 Summary - Hardware Delivery (Continued)

Tab 2 Summary - Hardware Delivery (Continued)	CY 60											
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IV - Non-orbit Test Vehicles												
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III - Orbit Stage Test Vehicles												
IV - Non-orbit Test Vehicles												
V - Orbit Test Vehicles OTV & PTV	1			1		1	1		1		1	

Tab 2 Summary - Hardware Delivery (Continued)	CY 62											
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IV - Non-orbit Test Vehicles												
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Tab 2 Summary - Hardware Delivery (Continued)	CY 63											
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III - Orbit Stage Test Vehicles												
IV - Non-orbit Test Vehicles												
V - Orbit Test Vehicles OTV & PTV												

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Subsystem I - ~~AIRBORNE TEST~~

Tab 2 Summary - Subsystem Test Schedule

1
2 STV Subsystem Tests at LACSTF
3 STV Flight Tests at AFMTC
4
5
6 OSTV Subsystem Tests at LACSTF
7 OSTV Captive Tests at LACSTF
8
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10 NOTV Subsystem Tests at LACSTF
11 NOTV Flight Tests at AFMTC
12
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14 OTV & PTV Subsystem Tests at LACSTF
15 OTV & PTV Flight Tests at AFMTC
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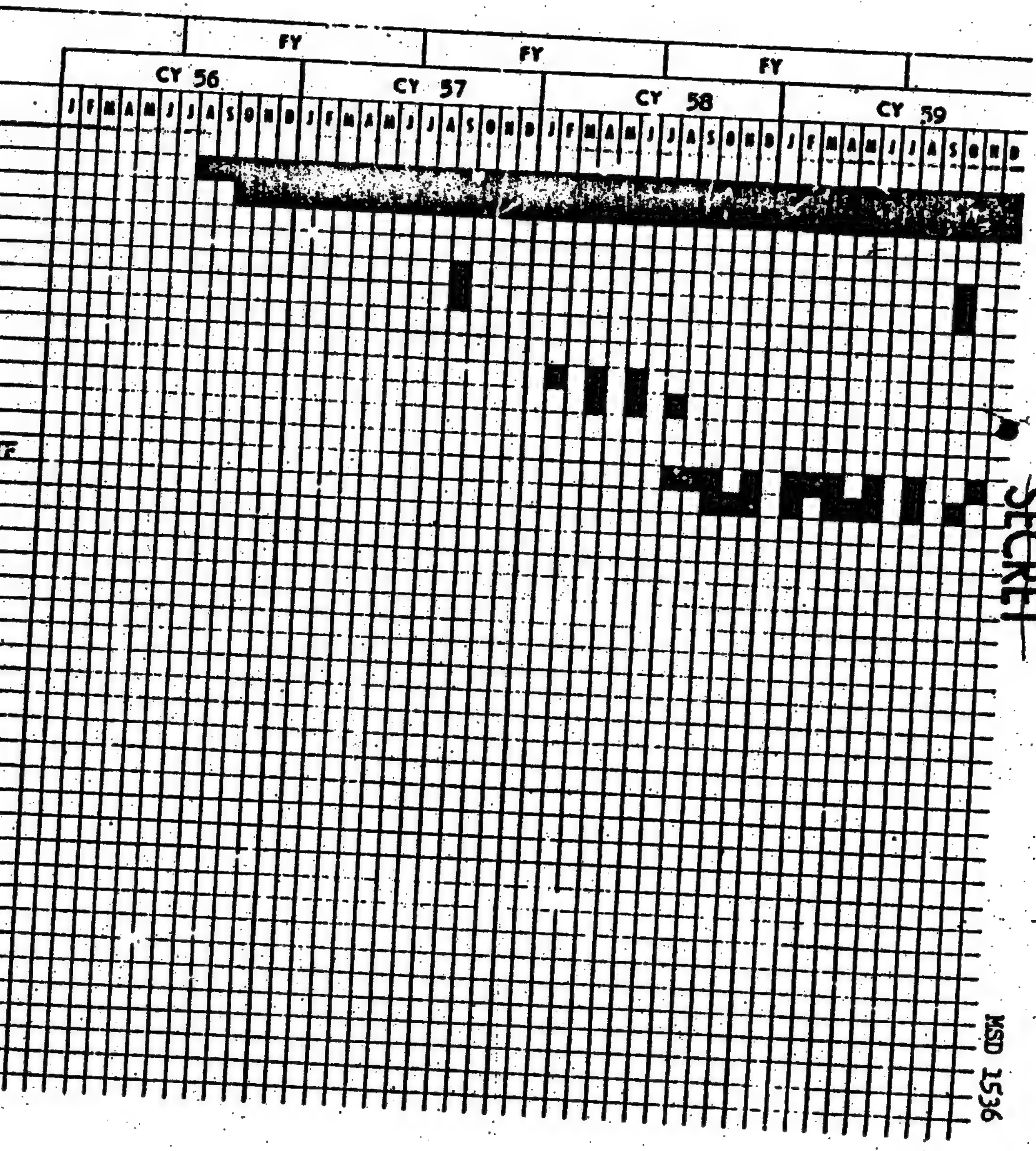

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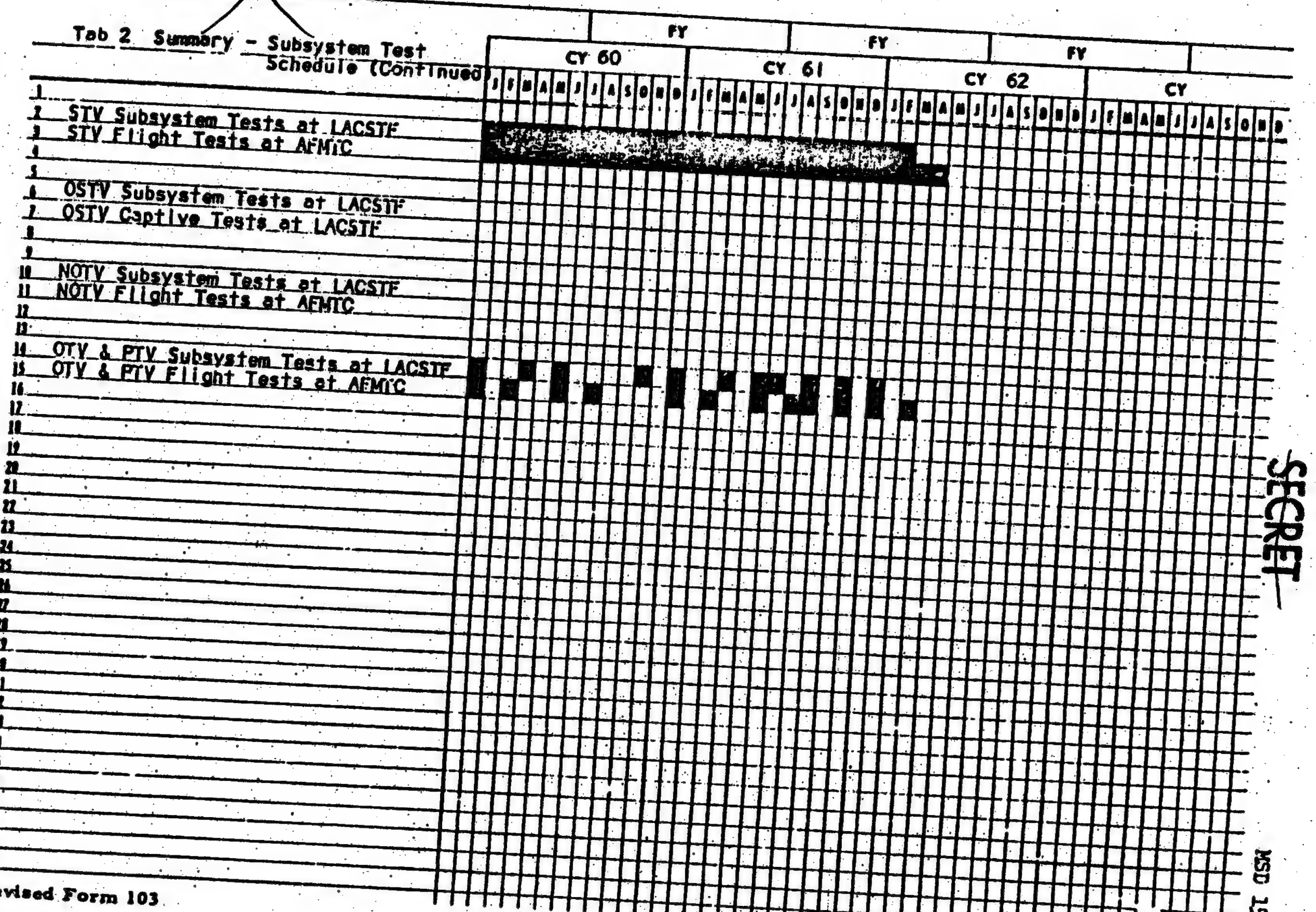
Subsystem I - AIRBORNE TEST

Tab 2 Summary - Subsystem Test Schedule (Continued)



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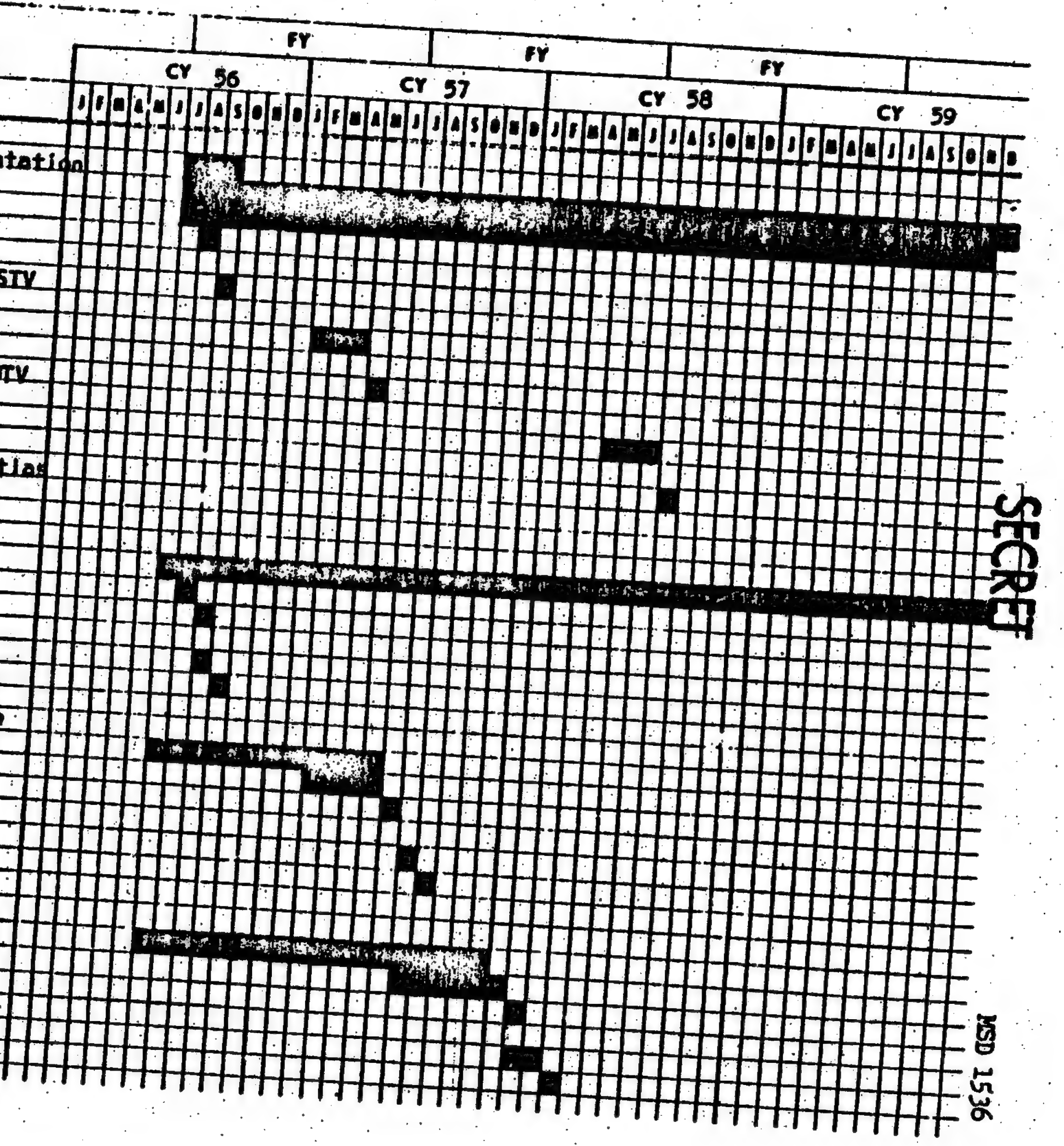
Subsystem I - ~~AIRBORNE~~ TEST

Tab 2 Summary - R & D Schedule



Task I - Airborne Test Instrumentation
- A. Research and Design
- B. Laboratory Test
- C. Fabrication of First STV Equipment
- D. Compliance Tests of First STV Equipment
- E. Fabrication of First OTV Equipment
- F. Compliance Tests of First OTV Equipment
- G. Fabrication of First Atlas Booster Equipment
- H. Compliance Tests of First Atlas Booster Equipment

Task II - Systems Test Vehicle
- A. Research and Design
- B. Fabrication of First STV
- C. Equipment Checks and Modification
- D. System Tests
- E. First Flight Test

Task III - Orbit Stage Test Vehicle
- A. Research and Design Begins
- B. Fabrication of First OSTV
- C. Equipment Checks and Modifications
- D. System Tests
- E. First Operational Test

Task IV - Non-orbit Test Vehicle
- A. Research and Design
- B. Fabrication of First NOTV
- C. Equipment Checks and Modification
- D. System Tests
- E. First Flight Test

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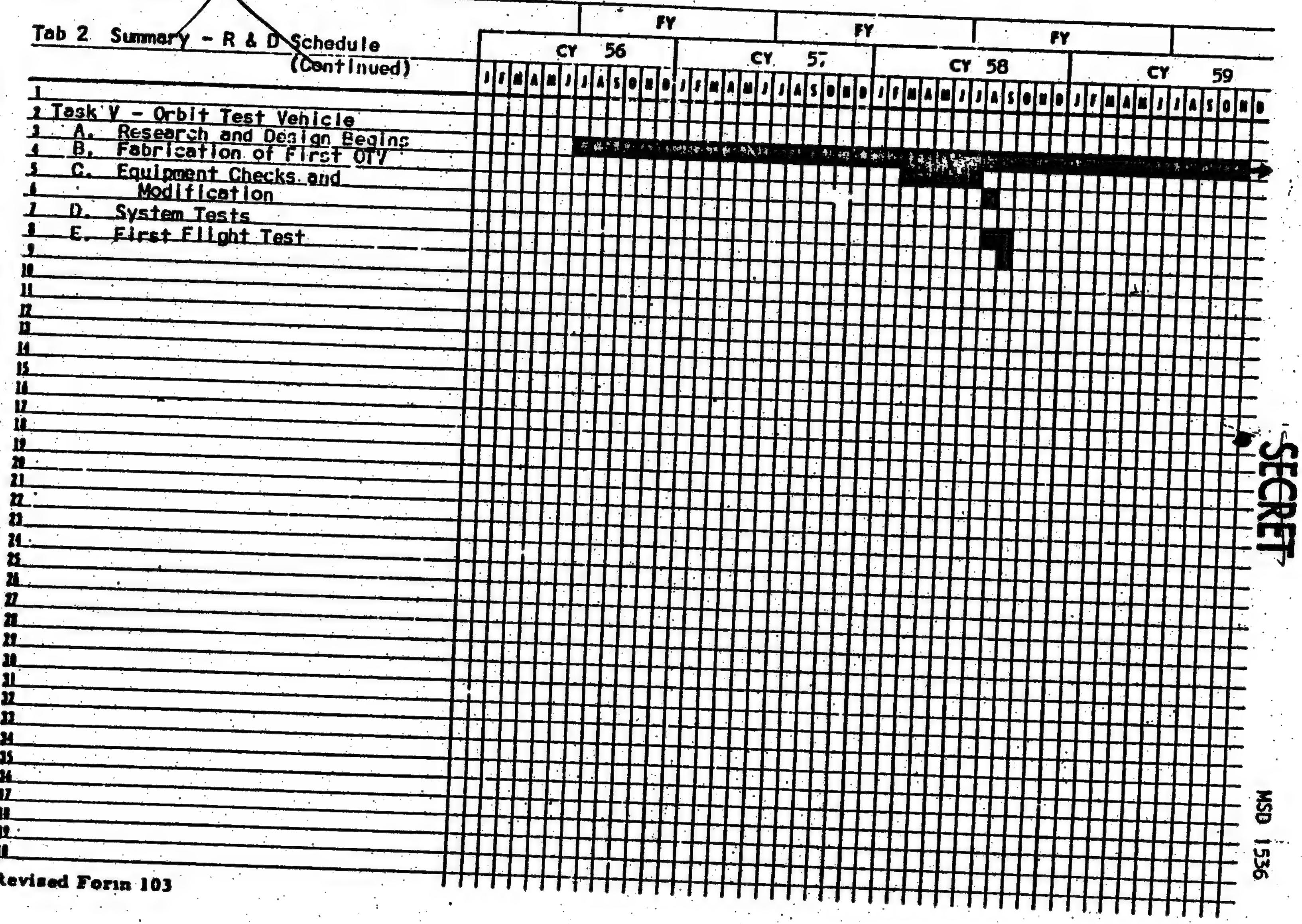
Subsystem I - AIRBORNE TEST

Tab 2 Summary - R & D Schedule (Continued)



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1.

R & D TEST ANNEX

☐ SYSTEM ☒ PROJECT ☐ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

PAGE 1 OF 1 PAGES

3. DATE 1 March 1956

4. TITLE 1 - AIRBORNE TEST SUBSYSTEM

5. INITIAL ☒ CHANGE

6. NUMBER

7. RESP CENTER

8. PROJECT OFFICER

9. SUPPORTS (Sys or Proj)

10. CONTRACTOR Lockheed MSD

11. CONTR NR AF33(616)-3105

12. PRIORITY AND PREC

13. SECURITY Secret

14. ITEM NUMBER	15. TEST ITEM	16. TEST DESCRIPTION	17. TEST AGENCY AND SITE	18. TEST ITEM AVAILABLE	19. RQD TEST COMPL DATE
1	Systems Test Vehicle	Checkout and Functional Tests	LACSTF	Recurrent*	Recurrent*
2	Systems Test Vehicle	Equipment Installation and Preflight Test	AFMTC	Recurrent*	Recurrent*
3	Orbit Stage Test Vehicle (No. 1)	Checkout and Functional Tests	LACSTF	Aug. 1957	Sept. 1957
4	Orbit Stage Test Vehicle (No. 2)	Checkout and Functional Tests	LACSTF	Sept. 1959	Oct. 1959
5	Non-orbiting Test Vehicle	Checkout and Functional Tests	LACSTF	Recurrent*	Recurrent*
6	Non-orbiting Test Vehicle	Equipment Installation and Preflight Test	AFMTC	Recurrent*	Recurrent*
7	Orbital Test Vehicle	Checkout and Functional Tests	LACSTF	Recurrent*	Recurrent*

* LACSTF Occupancy approximately one month per vehicle.
AFMTC Occupancy approximately two months per vehicle.
See Tab 2 for Test Schedule.

TEST CENTER APPROVAL

20. NAME ORGANIZATION

21. NAME ORGANIZATION DATE

DATE

RESPONSIBLE CENTER APPROVAL

22. NAME ORGANIZATION DATE

ARDC FORM 1 JUL 56 185 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

~~SECRET~~

MSD 1536

1\.

R & D TEST AND TEST SUPPORT AIRCRAFT ANNEX

☐ SYSTEM ☒ PROJECT ☐ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

PAGE 1 OF 1 PAGES

3. DATE 1 March 1956

4. TITLE Subsystem I - AIRBORNE TEST

5. INITIAL ☐ CHANGE

6. NUMBER

7. ITEM NUMBER	8. AIRCRAFT REQUIRED			9. ASG CODE	10. MOD REQD	11. DATE REQD AND LOCATION	12. ESTIMATED RELEASE DATE	13. RECOMMENDED DISPOSITION	14. F HRS P EST	15. EST COST
	QTY	TYPE, MODEL AND SERIES	SERIAL NUMBER							

AIRCRAFT WILL NOT BE REQUIRED FOR AIRBORNE TEST SUBSYSTEM.

ARDC FORM 1 JUL 55 186 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

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MSD 1536

1.

R & D MATERIEL ANNEX

☐ SYSTEM ☒ PROJECT ☐ TASK ☐ OTHER

2. REPORTS CONTROL SYMBOL

PAGE 1 OF 1 PAGES

3. DATE
1 March 1956

4. TITLE
Subsystem I - AIRBORNE TEST SYSTEMS

5. INITIAL ☐
CHANGE

6. NUMBER

7. MATERIEL REQUIREMENTS (Indicate Items in Columnar Form using Columns as cited in Examples)

R & D Materials other than Vehicle Test Systems cannot be defined at this time.

ARDC FORM 1 JUL 55 107 PREVIOUS EDITIONS OF THIS FORM ARE OBSOLETE.

SECRET

SUBSYSTEM I - ~~AIRBORNE~~ TEST SUBSYSTEM

DATE I March 1956

ITEM: IN PLANT TEST FACILITY *
SYSTEM TEST FACILITY *
AFMTC *

USING AGENCY: LOCKHEED MSD

LOCATION:

BUDGET CONTROL ESTIMATE:

NEED DATE:

SCHEDULE:	1956						1957												1958												1959											
	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D

DESCRIPTION AND UTILIZATION:

* Complete description of these facilities are given in Tab 6 - Subsystem L - Vehicle Ground Support

REMARKS:

Revised Form 108

Tab 7

R & D Contract Funds

Subsystem I - Airborne Test Systems

Subsystem I. TEST SYSTEM

Tab 7. R & D Contract Funds (in thousands of dollars)

	FY 57				FY 58				FY 59				FY 60	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
LAC														
(1) Research and Engineering	35	51	78	125	142	162	139	209	224	199	214	229	134	214
(2) Fabrication	35	35	36	52	62	73	95	109	109	85	83	83	55	93
Sub Total	71	86	115	177	204	241	234	319	334	284	297	312	260	307
CBS	15	34	50	51	86	98	103	122	120	120	112	112	85	92
Sub Total	87	131	165	229	290	339	387	441	454	404	409	424	345	400
Fee	9	13	13	22	29	33	38	44	45	40	40	42	34	40
TOTALS*	96	144	132	252	320	374	426	486	500	444	451	468	380	440
Total fiscal year				574				1606				1863		

*Differences in totals due to rounding

Subsystem I. TEST SYSTEM

Tab 7. R & D Contract Funds (in thousands of dollars) (Cont'd)

	FY 60		FY 61				FY 62				FY 63			
LAC	15	16	17	18	19	20	21	22	23	24	25	26	27	TOTALS
(1) Research and Engineering	244	259	279	259	249	239	209	194	206	206	206	206	127	5,157
(2) Fabrication	76	132	145	125	131	145	107	117	111	156	195	48	-0-	2,525
Sub Total	321	391	425	384	381	385	317	312	317	363	401	255	127	7,682
CBS	95	87	87	85	97	120	147	149	157	152	134	117	87	2,7[illegible]
Sub Total	416	479	513	469	479	505	464	462	475	515	536	372	214	10,417
Fee	41	47	51	46	47	50	46	45	[illegible]	51	53	37	21	1,041
TOTAL*	458	527	565	517	527	556	511	509	523	567	590	410	236	11,459
Total Fiscal year		1805			2165				2110			1236		11,459

*Difference in totals due to rounding

Tab 8

Estimate of Manpower Requirements

Subsystem I - Airborne Test Systems

Subsystem I TEST SYSTEM - AIRBORNE

Tab 8 Estimate of Manpower Requirements

WORK ITEM	Type of Manpower	1	2	3	4	5	6	7	8	9	10	11	12	13	14
LAC - Research and Engineering	1-2-3 *	7	12	15	20	27	32	37	41	44	39	43	46	39	43
LAC - Fabrication and Assembly		10	10	10	17	17	20	27	31	31	24	24	24	19	27
Sub-total		17	22	25	37	44	52	64	72	75	63	67	70	58	70
LMS - Scientific and Engineering	1	1	3	4	5	6	7	7	9	8	8	7	7	6	7
LMS - Engineering Support	2	2	3	5	6	9	10	11	12	12	12	12	12	8	8
LMS - Manufacturing	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub-total		3	6	9	11	15	17	18	21	20	20	19	19	14	15
Total		20	28	34	48	59	69	82	93	95	83	86	89	72	85
*Average															
40% Type 1															
50% Type 2															
10% Type 3															

Subsystem I TEST SYSTEM - AIRBORNE

Tab 8 Estimate of Manpower Requirements (cont'd)

WORK ITEM	Type of Manpower	15	16	17	18	19	20	21	22	23	24	25	25	27		Total Man Quarters
LA2 - Research and Engineering	1-2-3 *	49	52	56	52	50	48	42	39	41	41	41	41	25		
LA2 - Fabrication and Assembly		22	38	42	36	38	42	31	34	32	45	56	14			
Sub-total		71	90	93	88	88	90	73	73	73	86	97	55	25		1743
CSS - Scientific and Engineering	1	8	7	7	6	7	8	9	8	9	9	8	7	5		
CSS - Engineering Support	2	7	7	7	8	9	12	16	18	18	17	15	13	10		
CSS - Manufacturing	4	0	0	0	0	0	0	0	0	0	0	0	0	0		
Sub-total		15	14	14	14	16	20	25	26	27	26	23	20	15		462
Total		86	104	112	102	104	110	98	99	100	112	120	75	40		2205
*Average																
40% Type 1																
50% Type 2																
10% Type 3																

~~SECRET~~

Pied Piper

MSD 1536

LOCKHEED AIRCRAFT CORPORATION
MISSILE SYSTEMS DIVISION

APPENDIX

~~SECRET~~

SUBSYSTEM I

AIRBORNE TEST SYSTEMS

APPENDIX

1. INSTRUMENTATION

Instrumentation on the early flights will require the full capacity of the telemetering system to obtain data on environmental conditions peculiar to the Pied Piper vehicle and subsystems operation. Information priority will be given to the following in their respective order: System Performance, Environmental Data needed for design information, and Geophysical Data needed to determine effect on flights and equipment.

Later flights will require the instrumentation of the various payload systems to determine their operation in the Pied Piper environment as established by the prime objectives of each flight. Information channels not utilized for the prime objectives will be used for additional environmental and geophysical data.

A detailed schedule of instrumentation requirements and prime objectives of each STV flight showing the utilization of available channels is compiled in Table 1.

Table 1

STV DATA SYSTEM

STV OBJECTIVE	QUANTITY	CHANNELS UTILIZED Commutated	 Continuous
1 Non-Separating, Environmental checks, telemetering system test, destruct system, beacon, booster, airframe	Telemetering	6	
	Destruct System	6	
	Beacon	8	
	Primary Power	6	
	Acceleration	6	2
	Vibration		3
	Pressure	8	2
	Temperature	12	
	Strain Gages	10	2
	Roll Rate	2	
	Telltale		2
	Misc.	Remaining channels	
2 Same as STV 1			
3 Same as STV 1			
4 Same as STV 1			
5 Separation & Transition control checks, unlatching and operation of transition control jet units	Telemeter	6	
	Destruct	6	
	Beacon	8	
	Primary Power	6	
	Acceleration	6	1

Table 1 (Continued)

STV OBJECTIVE	QUANTITY	CHANNELS UTILIZED	
		Commutated	Continuous
5 (continued)	Vibration		3
	Pressure	8	2
	Temperature	12	
	Strain Gages	10	2
	Roll Rate	2	
	Telltale		2
	Transition Control Jet Units	12	3
	Misc.	Remaining channels	
6 Same as STV-5			
7 Same as STV-5			
8 Separation & Vernier System, Unlatching & operation of transition control Jet Unit, Attitude Control	Telemeter	4	
	Destruct	4	
	Beacon	8	
	Primary Power	4	
	Acceleration	6	1
	Vibration		2
	Pressure	8	2
	Temperature	8	
	Strain Gages	10	2
	Roll Rate	2	

Table 1 (Continued)

STV OBJECTIVE	QUANTITY	CHANNELS UTILIZED	
		Commutated	Continuous
	Telltale		2
	Separation	10	2
	Attitude Control	20	2
	Misc.	Remaining Channels	
9 Same as STV-8			
10 Prototype Orbital Stage Engine, Separation & Transition, Engine Test, Air Start, Control Shocks	Telemeter	4	
	Destruct	2	
	Beacon	6	
	Primary Power	2	
	Acceleration	6	1
	Vibration		2
	Pressure	8	2
	Temperature	8	
	Strain Gages	10	2
	Roll Rate	2	
	Telltale		2
	Separation	6	
	Attitude Control	12	2
	OS Engine	20	2
	Misc.	Remaining Channels	

Table 1 (Continued)

STV OBJECTIVE	QUANTITY	CHANNELS UTILIZED	
		Commutated	Continuous
11 Long-Range Propagation Test Flights	Telemeter	2	
	Destruct	2	
	Beacon	4	
	Primary Power	2	
	Acceleration	4	1
	Pressure	4	
	Temperature	4	
	Strain Gages	4	
	Roll Rate	2	
	Telltale		2
	Separation	4	
	Attitude Control	6	2
	Engine	6	
	Propagation Equipment	10	
	Propagation Information	20	2
	Misc.	Remaining Channels	
12 Same as STV-10			
13 Same as STV-11			
14 Flt. suitable OS	Telemeter	2	

Table 1 (Continued)

STV OBJECTIVE	QUANTITY	CHANNELS UTILIZED	
		Commutated	Continuous
engine, Attitude control, telemetered & photo-pickup	Destruct	2	
	Beacon	4	
	Primary Power	2	
	Acceleration	4	1
	Pressure	2	
	Temperature	4	
	Strain Gages	4	
	Roll Rate	2	
	Telltale		2
	Attitude Control	6	
	Engine	4	
	Photo-Pickup	20	2
	Misc.	Remaining Channels	
15 Same as STV-11			
16 Flt Suitability, OS engine, attitude control, film, read-out, of antennas	Same as STV-14 with film readout substituted for photo-pickup		
17 Flt suitability, OS engine, ferret (including tape recorder test)	Same as STV-14 with ferret substituted for Photo-pickup		

Table 1 (Continued)

STV OBJECTIVE	QUANTITY	CHANNELS UTILIZED	
		Commutated	Continuous
18 Flt suitability, OS engine, film system	Same as STV-14 with film system substituted for photo-pickup		
19 Flt suitability, OS engine, complete ferrets (inc. ant. programs)	Same as STV with ferret substituted for photo-pickup		
20 Flt suitable OS engine, complete visual	Same as STV-14 with visual substituted for photo-pickup		
21 Flt suitable OS engine, ferret mod. tests	Same as STV-14 with ferret substituted for photo-pickup		
22 Flt suitable OS engine visual mod. tests	Same as STV-14 with visual substituted for photo-pickup		
23 Flt suitable OS engine, OTV Mod. tests G & C, telemetering	Same as STV-14 with OTV Mod., & G & C substituted for photo-pickup		
24 Flt suitable OS engine, OTV Mod. Tests	Same as STV-14 with OTV Mod substituted for photo-pickup		
25 Flt suitable OS engine, APU power conversion system test	Same as STV-14 with APU substituted for photo-pickup		

Instrumentation for the NOTV and OTV flights must monitor vehicular functions sufficiently to give a reasonable likelihood of discovering the reason for any failure. In addition, the instrumentation must be sufficient to observe the environment, both geophysical and that peculiar to the vehicle. Some information on the geophysical environment can be expected from the IGY satellite, but because of its limited size, much more data will be required. In the following discussion, items on which information may be gathered by the IGY satellite are identified; it is not likely that all these will be investigated in that effort. Several of them may be, however, and with sufficient additional effort, all of them could be, although not as completely as would be possible with the Pied Piper.

From the time of launching through the period of orbiting flight, the following environmental factors relating to the orbiting vehicle will be monitored. These are summarized in Table 2.

1. Instrumentation section pressure (sudden drop might indicate skin puncture by meteor).
2. Temperature through the instrumentation section and on the skin.
3. Auxiliary power unit operation, including gas pressure and consumption, voltage and current output to frequency, and vibration of the unit.
4. Beacon, telemetering, and destruct system monitors; and operation of all payload systems as needed.
5. Vehicle aspect and attitude control system monitors.

Table 2

ORBITING STAGE DATA SYSTEM

		Commutated	Continuous
1.	**Vehicular functions and environment**		
a.	Pressure in instrumentation section	1	
b.	Temperature in instrumentation section	2	
c.	APU operation, gas pressure and consumption voltage, current etc.	6	
d.	Beacon, telemetering, destruct, monitors, & payload systems operation as needed	30	4
e.	Vehicle aspect and attitude control		2
2.	**Necessary Environmental Observations**		
a.	Meteor observation, microphone mounted on skin. 3" x 10" x 12", 10 lbs		2
b.	Drag data, ram pressure gauge mounted on forward side of missile, 6" x 10" x 3", 5 lbs.	1	
c.	Cosmic radiation, prolonged exposure effects, 6" x 10" x 2", 5 lbs.	1	
d.	R-F propagation experiment, 6" x 10" x 12", 20 lbs.	4	
e.	Albedo and nocturnal radiation, radiator pickup in tail, 3" x 10" x 12", 10 lbs.	1	

Table 2 (Continued)

ORBITING STAGE DATA SYSTEM

3. Supplemental Environmental Observations	Commutated	Continuous
a. Solar radiation, X-rays and Lyman alpha, 2 pickups on side of instrument section, 3" x 10" x 12", 10 lbs.	2	
b. Magnetic field, box away from magnetic disturbances, 6" x 10" x 12", 20 lbs.		1
c. Cosmic radiation, telescope and electronics near noze, 3" x 10" x 6", 5 lbs. (or larger)		1
d. Auroral particles, pickup (1" D x $\frac{1}{2}$") open to side, facing somewhat upward, 3" x 6" x 10", 5 lbs.		1
e. Ion composition, small side open to forward side of missile through 2-inch tube, 20" x 6" x 5", 20 lbs.		1

Items 1 through 4 could be handled on commutated information channels along with some of the measurements of geophysical environment. Item 5 would require two or three continuous information channels.

During orbiting flight, the following geophysical observations should be made.

1. Meteor observation
2. Drag data or atmospheric densities
3. Effects of prolonged exposure to cosmic radiation
4. R-F propagation experiments on total electron density in the ionosphere
5. Measurement of earth's albedo and nocturnal radiation and the radiation exchange with the vehicle
6. Observation of solar X-ray and Lyman alpha radiation
7. Magnetic field strength and direction
8. Cosmic radiation experiments
9. Observation of auroral particles
10. Ion composition and density
11. Geodetic data

The first five are necessary to ensure the success of the operation. While the remainder are of lesser importance to the program, they are of prime geophysical importance and may help the program, e.g., the magnetic field might be of use for guidance or attitude control. (Ref.1) presents a detailed discussion of these items.

From the time of booster separation until the final vernier velocity has been imparted to the orbiting stage vehicle, a number of functions relating to the propulsion and guidance systems must be monitored. For this reason, some of the instrumentation for the above items will probably have to relinquish their telemetering channels temporarily, but this will amount to an interruption of only a minute or so. The quantities to measure will consist mainly of pressure gages in the propulsion system, accelerometers, strain gages, and monitors of the various systems. In later orbiting vehicles, which will have a reliable reconnaissance data transmission link, the telemetering system will be simplified considerably; its main purpose will be to monitor operation of the subsystems because the reconnaissance data link will be able to handle complex environmental and geophysical information requirements. The simpler and more economical PWM/FM telemetering system can be utilized at this time.

Up to the time of booster separation, a second data handling system in the booster stage can be used to monitor booster stage functions and a few functions in the orbiting stage vehicle. These functions should be monitored from launching through booster separation; they are listed below and summarized in Table 3.

1. Temperatures will be measured at selected points in the booster stage and along the nose cone of the orbiting stage. These

Table 3

SECOND DATA HANDLING SYSTEM - BOOSTER STAGE TELEMETERING

	Commutated	Continuous
Temperature	50	
Pressure	50	
Vibration		3
Acceleration (Longitudinal)		1
Strain Gages	20	
Missile Attitude	4	3
Other vehicle functions	50	2

measurements will require 50 commutator positions of the telemeter system.

2. Pressure will be measured in the booster state propulsion system, and some ram pressure measurements may be made at the nose of the orbiting stage. These measurements will also require 50 commutator positions of the telemetering system.

3. Vibration measurements will be made at selected points and will require 3 telemetering channels.

4. A longitudinal accelerometer requires 1 telemetering channel.

5. Strain gages will be placed at selected locations, including the interconnect structure. These will require 20 commutated positions of the telemeter system.

6. Missile attitude will be monitored as fully as possible, and the indicators will include solar aspect indicators, horizon indicators, and magnetic field indicators. Four commutated positions and two continuous channels will be required. If recovery appears feasible, a camera may be included in the instrumentation.

7. Other vehicle functions, not specifically identified at this time, require 50 commutated positions and 2 continuous channels.

2. SYSTEM TEST VEHICLE

2.1 Performance

These estimates of STV performance are based on the results of X-17(RTV) firings. At burnout of the first stage, the altitude is about 70,000 feet and the speed about 5500 feet per second. For a payload weight of about 1600 pounds, the performance is expected to be better later in the program, but this performance gives an apogee of 460,000 feet. For no thrust in the second stage, this will permit a flight time of about 300 seconds to impact; during most of this time the vehicle will be above 100,000 feet. It is estimated that six minutes of this time (300 seconds) will be useful for testing payload components. It is estimated that a second stage with 3000 pounds of propellant in a gross weight of 5000 pounds would allow a payload of about 1000 pounds to be kept above 300 n. miles altitude for about 10 minutes. The expected performance is given in Ref. 1.

2.2 Aerodynamics

The aerodynamic design of the STV was separated into two configuration studies: one without the OTV propulsion system and the other with the propulsion system complete with vernier control engines.

The configuration without the OTV propulsion unit is a high-fineness-ratio cone-cylinder body with the cylindrical portion having a diameter equal to that of the T-65 Sergeant rocket.

The vernier control engines of the configuration with the OTV propulsion unit extend beyond the 31-inch diameter envelope of the booster rocket and must be protected by two fairings, 180 degrees apart. These fairings must be sufficiently large to permit rotation of the control engines. The relatively forward location of these fairings introduces a destabilizing moment and increases the requirements of the stabilizing surfaces of the vehicle, but the magnitude of this destabilizing moment is small. Thus it is possible to use the same stabilizing surfaces for both configurations with no appreciable performance degradation for the configuration without the OTV propulsion system.

The pertinent aerodynamic characteristics of each configuration were estimated and used to calculate typical boost trajectories (see Figs. 2-1 and 2-2). These trajectories are very similar to those of the Lockheed X-17 Re-Entry Test Vehicle; thus it was possible to apply the aerodynamic heating data obtained for the X-17 to the present configuration (see Fig. 2-3). The trajectory data were also used to estimate gust loads and bending moments at the separation joint.

The test vehicle itself is aerodynamically unstable when separated from the booster, but if the separation is delayed for a few

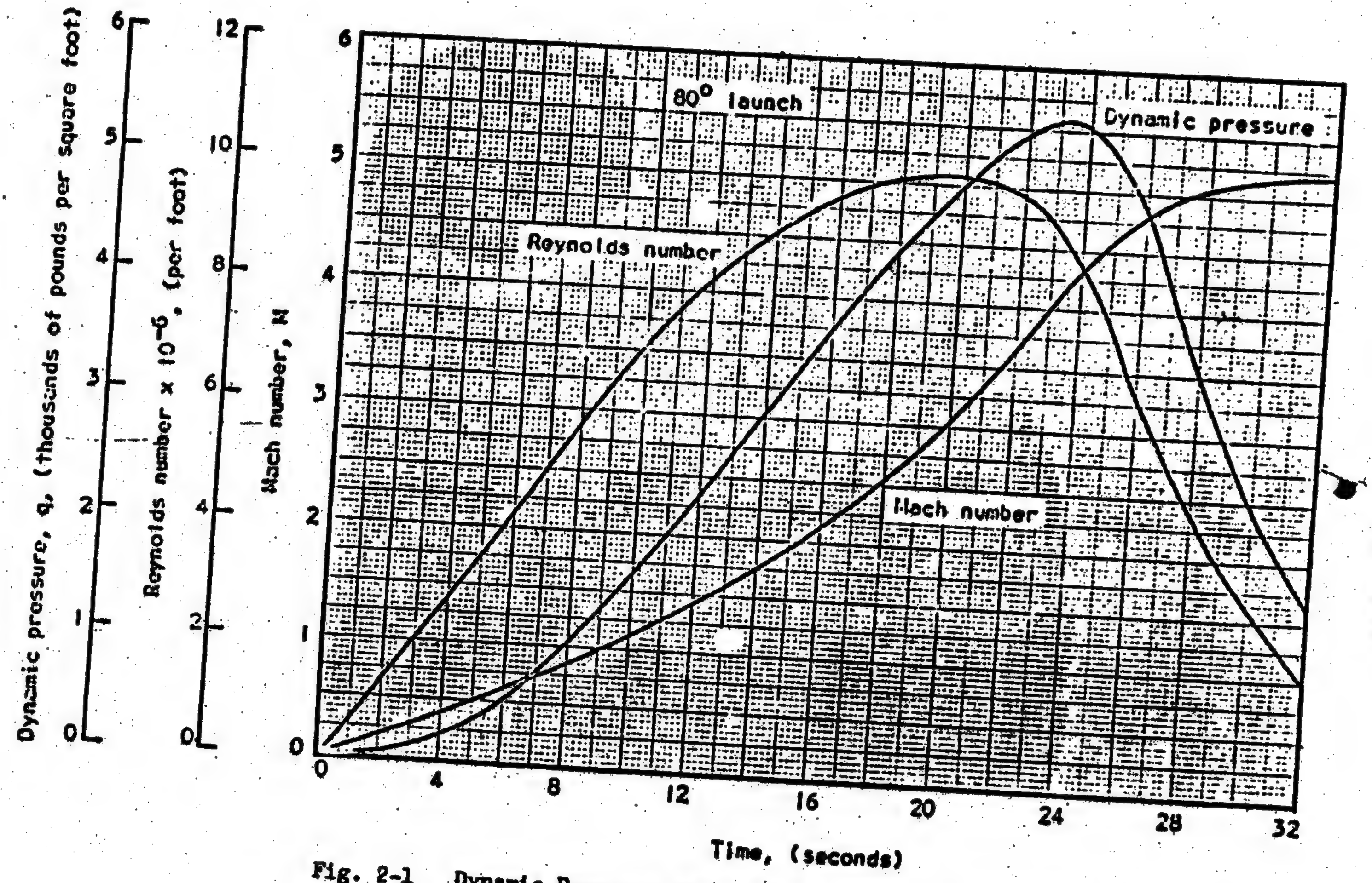

Fig. 2-1 Dynamic Pressure, Reynolds Number, and Mach Number vs STV Boost Trajectory (Configuration Without OTV Propulsion System)

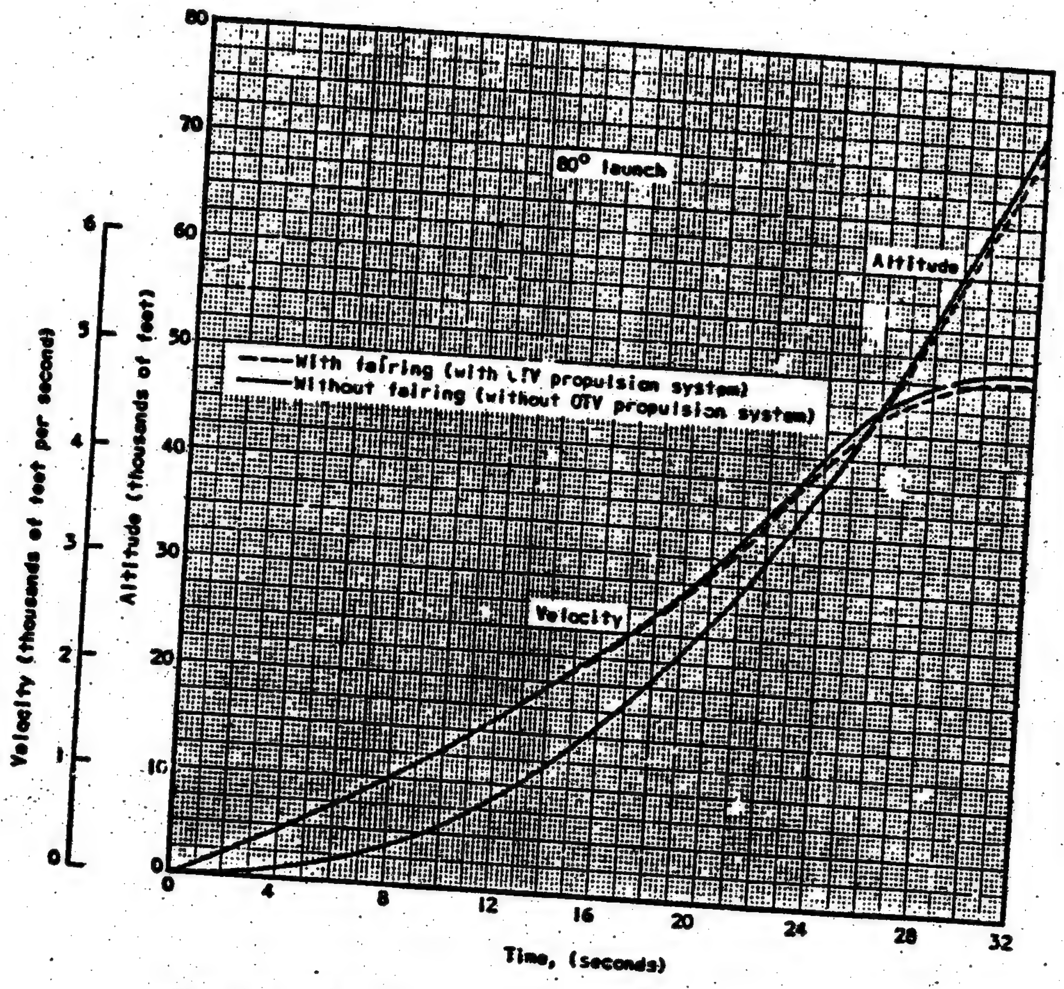

Fig. 2-2 Velocity and Altitude vs Time for STV Boost Trajectory (Configurations With and Without OTV Propulsion System)

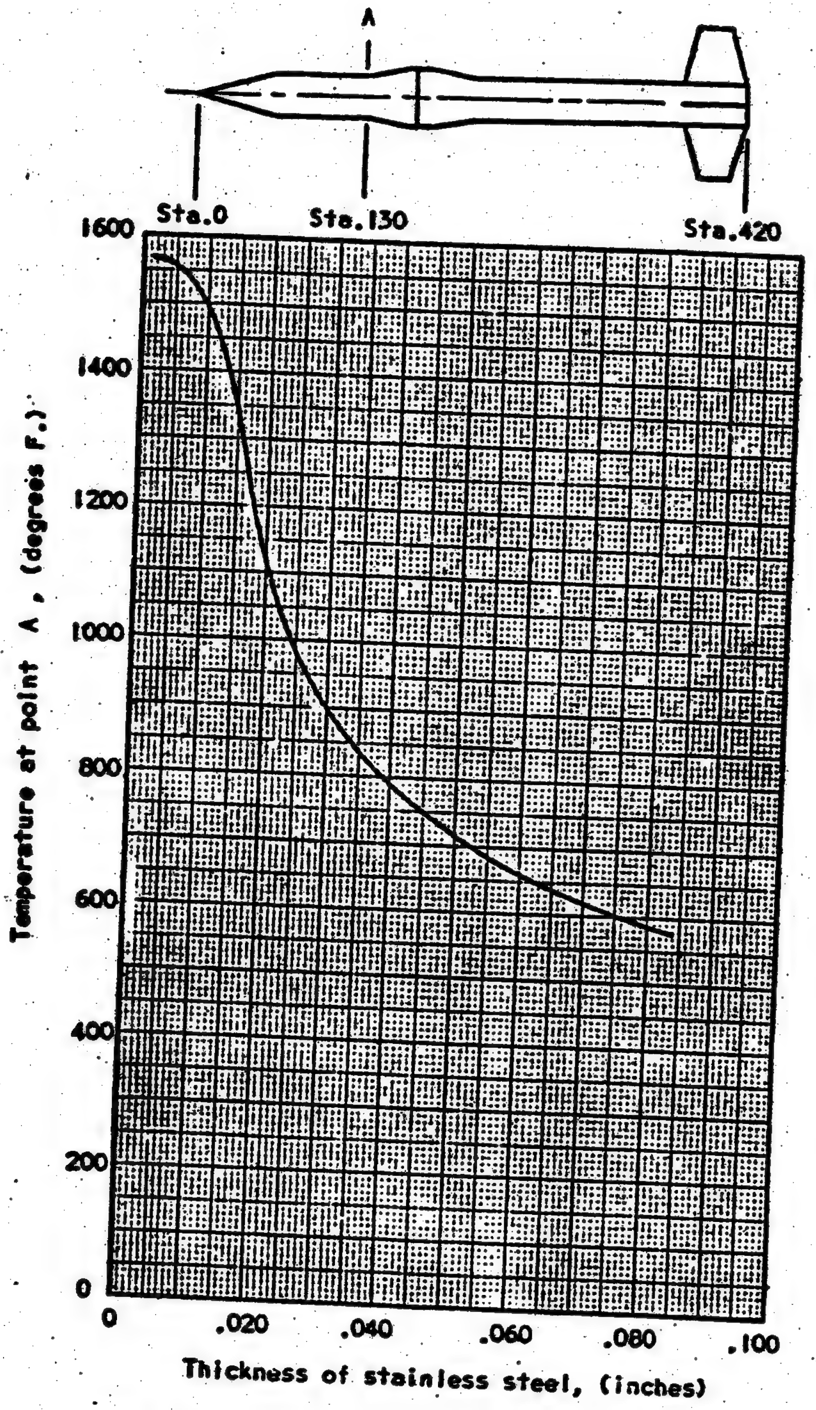

Fig. 2-3 Maximum Skin Temperature vs STV Skin Thickness

seconds after booster burnout, the configuration coasts up to altitudes of relatively low density where the vernier control engines can overcome the destabilizing aerodynamic moments.

2.2.1 Drag Coefficients

The total zero lift drag is composed of the skin friction of the wetted area of the configuration, the wave drag of the nose and the fins, the wave and boat tail drag of the vernier engine fairings, and the base drag of the area of the base not occupied by the rocket nozzle.

The friction drag was estimated by use of the turbulent skin friction data on cone-cylinder bodies of revolution given in Ref. 2. In this reference it is shown that the ratio of compressible skin friction to incompressible skin friction is insensitive to Reynolds Number. The variation of this ratio with Mach number can be approximated by the relation

$$\frac{c_f}{c_{f_i}} = \frac{1}{(1 + .18M^2)^{\frac{1}{2}}}$$

Thus the skin friction drag over the desired Mach number range can be obtained by an extrapolation of the incompressible skin friction.

The wave drag of the conical nose was obtained from the cone pressure data of Ref. 3. The effect of the slight spherical blunting of the cone tip is small and has consequently been neglected.

The pointed cone drag value is considered conservative because the data of Ref. 3 show that small degrees of spherical bluntness on cone tips produce a slight decrease in drag. The fin wave drag was calculated by the conventional equation for a biconvex airfoil.

The vernier control engine fairings are the only protuberances on the cone-cylinder body. The fairings are a combination of a half cone which fairs into a wedge. For purposes of drag estimation, it was assumed that the drag of the fairings was midway between that for a pure wedge and that for a pure cone with the appropriate semivertex angle.

Base drag was assumed to act over the area of the base not occupied by the rocket nozzle. Estimates of the base drag coefficients to be applied to this area were obtained from Ref. 5.

The calculated variation of zero lift drag coefficient with Mach number is presented in Fig. 2-4. Curves are shown for the configuration with and without the vernier control engine fairings to indicate the incremental drag of the fairings.

2.2.2. Lift Coefficients and Center of Pressure

The total lift of the configuration is made up of cone-cylinder body lift, lift of the vernier control engine fairings, and fin lift which will be assumed to include the mutual interference lift of the body on the fins and of the fins on the body.

The lift and center of pressure of the cone-cylinder were estimated from available data on various body configurations such

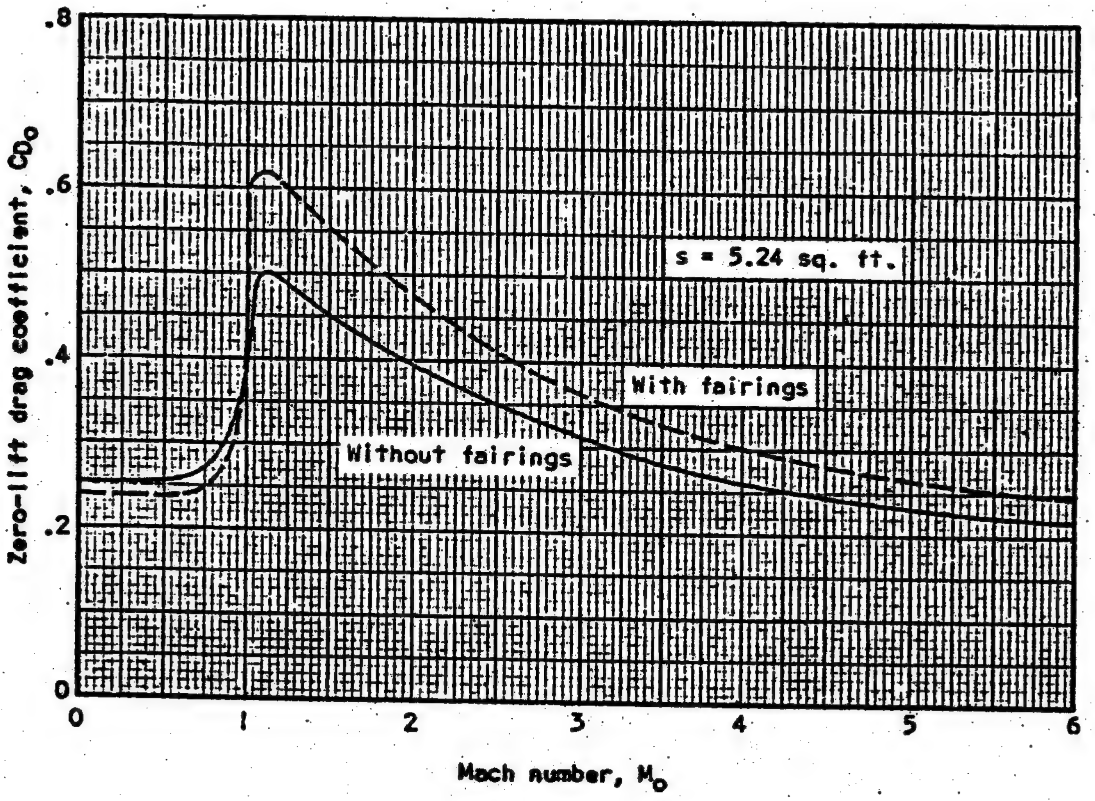

Fig. 2-4 Zero-Lift Drag Coefficient vs Mach Number for the STV Configurations

as Refs. 6, 7 and 8. The vernier control engine fairings were assumed to act as conical lifting surfaces.

The isolated fin lift was obtained from Ref. 9 for Mach numbers greater than 1, and from the equation

$$C_{L_{\alpha_F}} = \frac{c_{l_\alpha}}{\frac{1}{\sqrt{\cos\Lambda}} + \frac{1}{A} + \frac{18.24\, c_{l_\alpha}}{A}}$$

for Mach numbers less than 1, where

$C_{L_{\alpha_F}}$ = slope of the lift curve of isolated fins

Λ = sweep angle of quarter chord line

c_{l_α} = section lift curve slope

For supersonic speeds, the effect of the body on fin lift and center of pressure were obtained by the method of Ref. 10. The effect of the fin on body lift was obtained from Ref. 11, which considers wing-body combinations with no afterbody. The interference lift at subsonic speeds was calculated by a method given in Ref. 12. The subsonic center of pressure was assumed to be at the quarter chord of the fin.

Curves showing the calculated variations of lift coefficient slope and center of pressure with Mach number are presented in Figs. 2-5 and 2-6. Calculations were made for the configuration with and without the vernier control engine fairings to show the effect of the fairings.

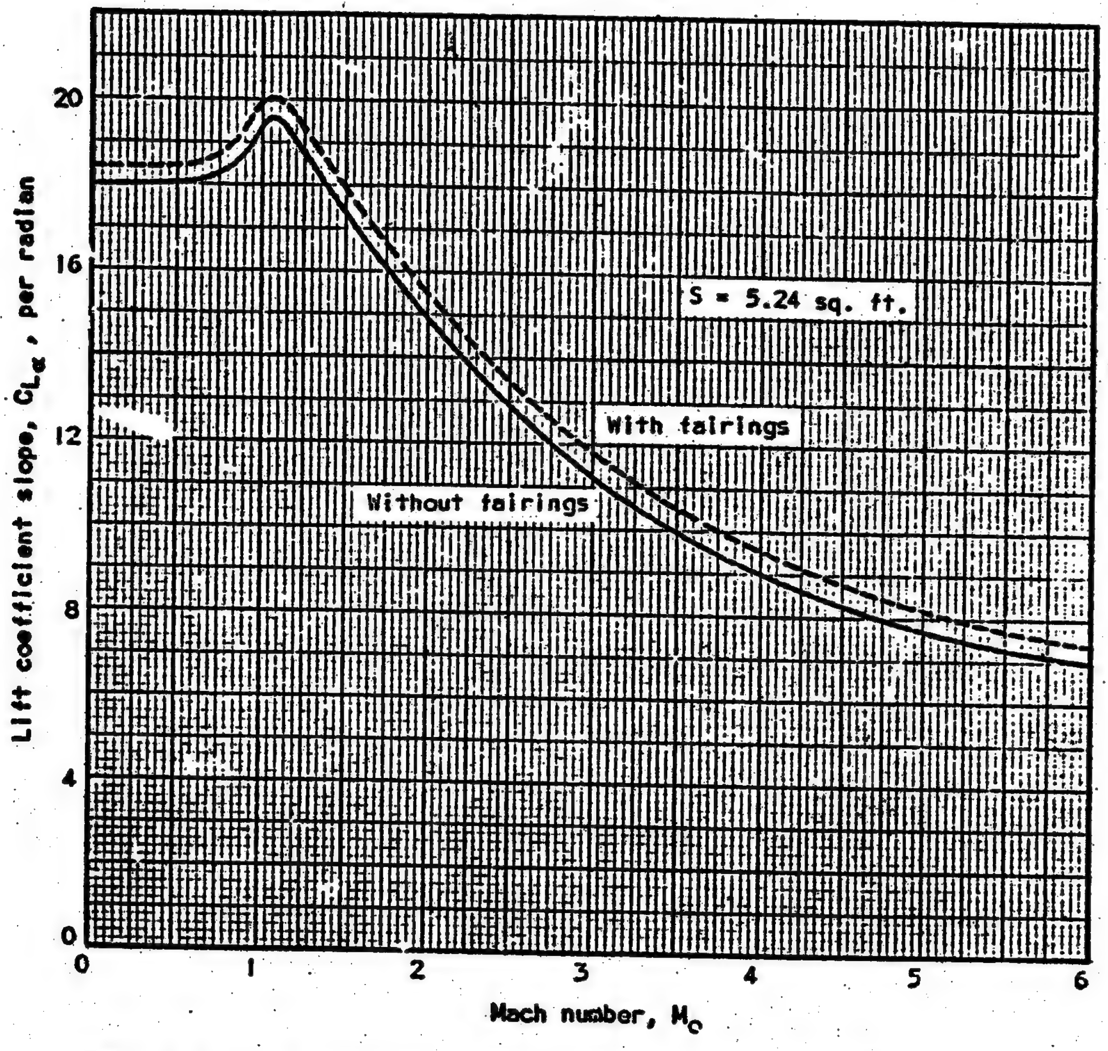

Fig. 2-5 Lift Coefficient Slope vs Mach Number for the STV Configurations

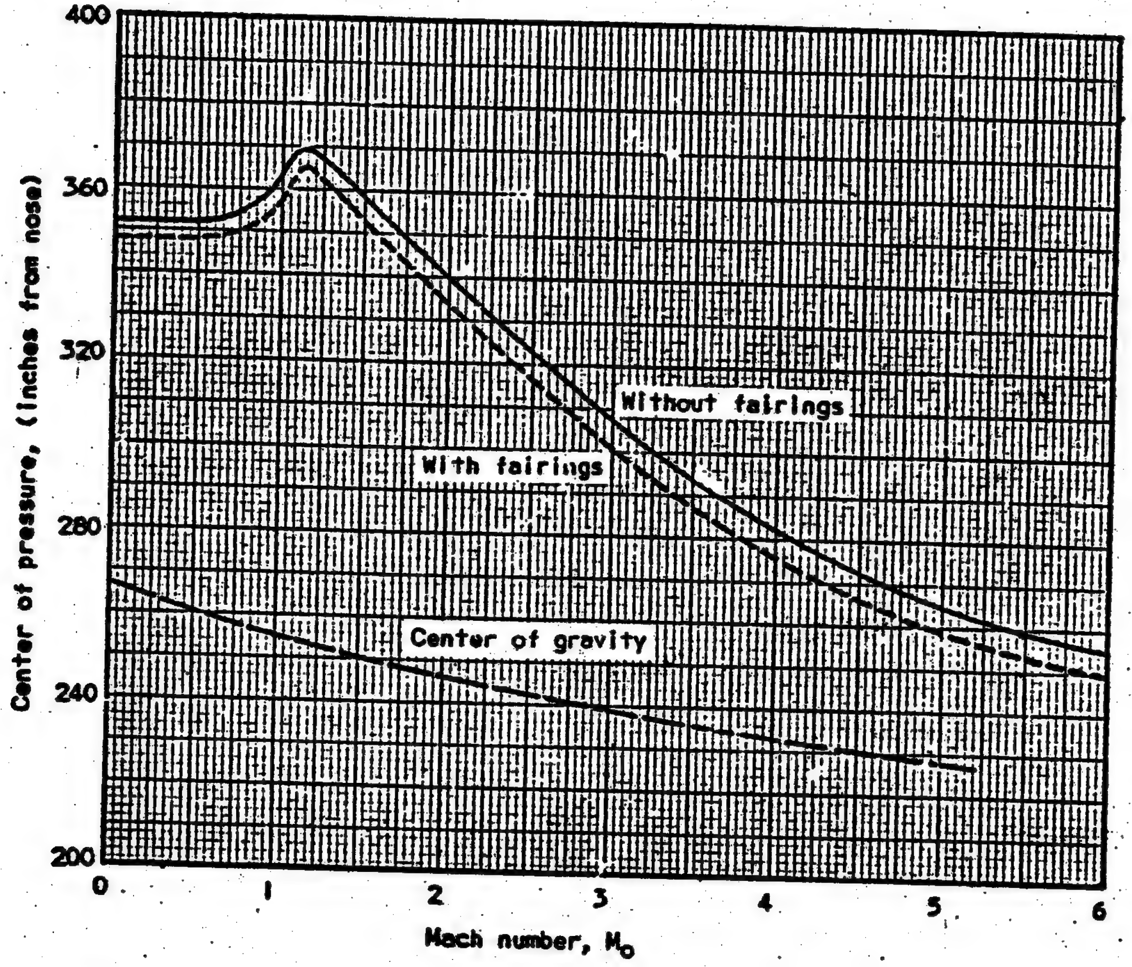

Fig. 2-6 Center of Pressure and Center of Gravity vs Mach Number for the STV Configurations

2.3 Structures

The structural analysis of the System Test Vehicle (see Fig. 2-7) is given on the following pages.*

The tanks, made of welded AM350 stainless steel, are similar to those for the OTV except that the volumes are smaller. The engine installation is identical to that for the OTV. Thus the spherical radius at the bottom of the WFNA tank is the same in both cases.

Since this vehicle travels at a greater speed than the OTV, the aerodynamic heating is much greater. The temperature of the 0.032-inch shell is 860 degrees F at Station 167. Since magnesium has a strength limit temperature of 500 degrees F, AM350 stainless steel must be used.

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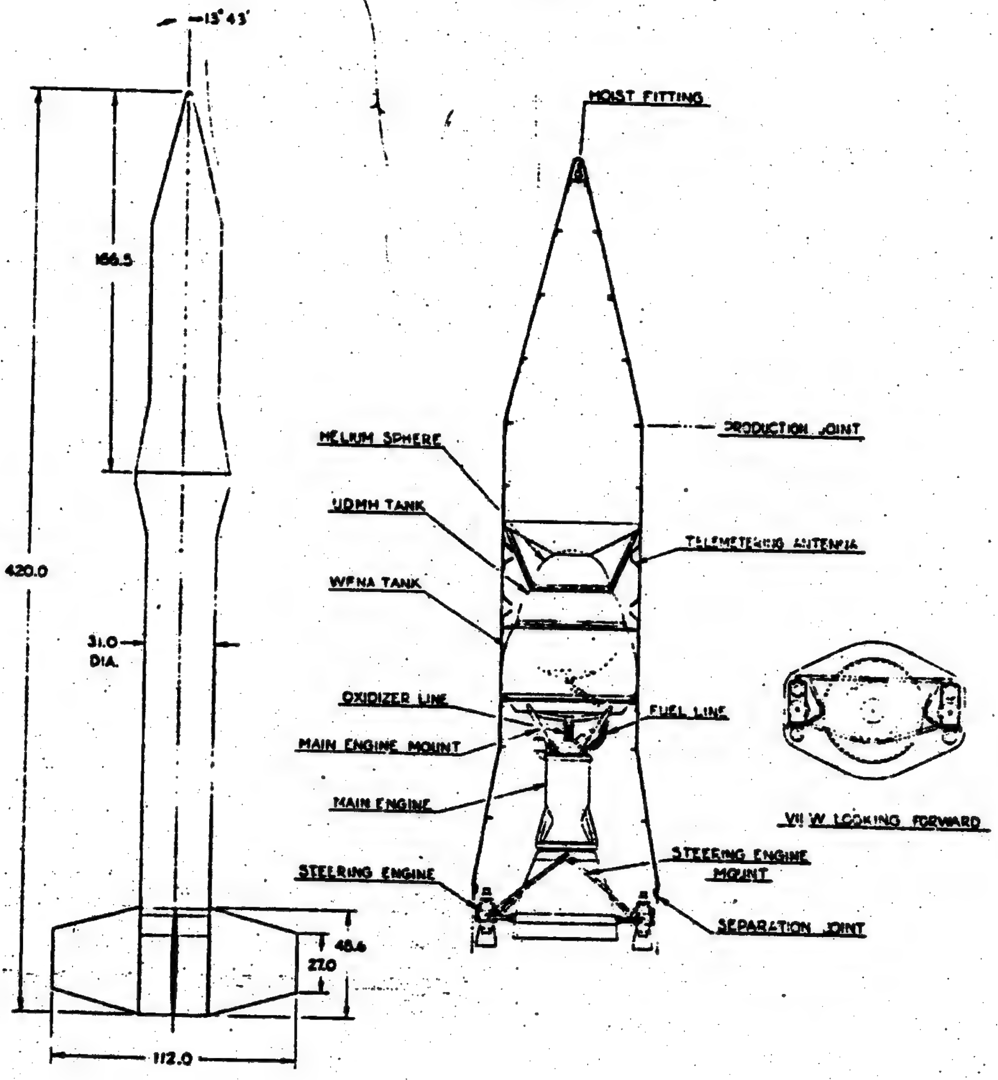
* The OTV structure is discussed in the Appendix to Subsystem A - Airframe.

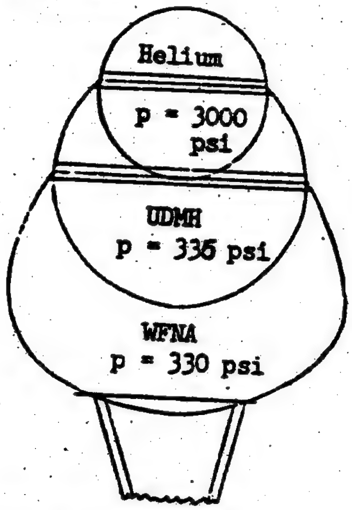


SYSTEM TEST VEHICLE

Fig. 2-7

System Test Vehicle

Tank Gages



Condition: $t = 23.5$ sec; $h = 37{,}500$ ft
$n_z = 12.5$ (Ref. STV Trajectory)

Helium Tank:

$d = 17.3$ in.

$v = 1350 \text{ in}^3$

$$t = \frac{3000 \times 17.3}{4\ (112{,}200)} = 0.115$$

Use $t = 0.125$ in.
(AM350 Stainless Steel)

UDMH Tank:

$d = 24.10$ in

$v = 5500 \text{ in}^3$

$$t = \frac{335 \times 24.1}{4\ (112{,}200)} = 0.018 \text{ in.}$$

Use $t = 0.020$ in.

WFNA Tank:

$d_{\text{upper sphere}} = 31$ in.

$d_{\text{lower sphere}} = 54$ in.

$v = 8100 \text{ in.}^3$

$$t = \frac{330 \times 31}{4(112{,}200)} = 0.023 \text{ in.}$$

Use $t = 0.032$ in.

$$t = \frac{330 \times 54}{4(112{,}200)} = 0.040 \text{ in.}$$

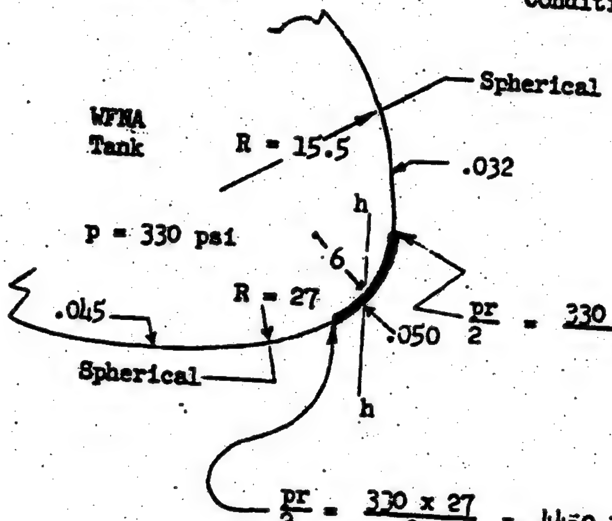
Use $t = 0.045$ in.

(Same as OTV)

System Test Vehicle

Tank Ring

Condition: t = 23.5 sec; h = 37,500 ft
h_z = 12.5 (Ref. STV Trajectory)



$\frac{pr}{2} = \frac{330 \times 15.5}{2} = 2560$ lb/in

Hoop and longitudinal

$\frac{pr}{2} = \frac{330 \times 27}{2} = 4450$ lb/in

Hoop and longitudinal

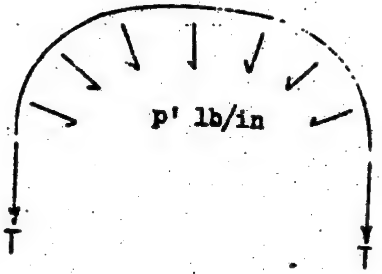
Hoop tension B = 4450
Hoop tension C = 2560

Average = 3505 lb/in

3505 x 8 = 28,000 lb

$T = \frac{3850 \times 30}{2} - 28,000$

= 30,000 lb



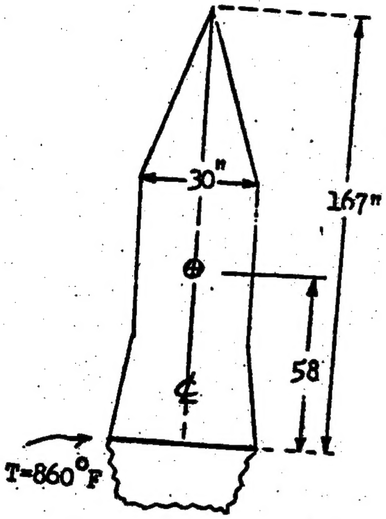
Effective loading = $\frac{30,000}{15}$ = 2000 lb/in = p'

$I_{h\text{-}h}$ required = $\frac{p' \times 1.25 \times r^3}{3E} = \frac{2000 \times 1.25 \times 3400}{3 \times 30 \times 10^6}$ = 0.095 in^4 for ring buckling

$Area_{required} = \frac{30000 \times 1.25}{100,000}$ = 0.375 in^2 t = 0.050 in. is adequate

where 100,000 psi is comp. yield limit x 85 per cent.

Shell Structure



Condition: $t = 23.5$ sec $h = 37{,}500$ ft
$n_z = 12.5$ (Ref. STV
$n_x = 1.5$ Trajectory)
plus gust of 70 feet per second

$W_G = 1600$ lb $n_z = 12.5$

Axial load = 20,000 lb

Moment due to n_x:
$n_x = 1.5$ $M = 1600 \times 1.5 \times 58 =$
$-139{,}000$ in. lb $\times 1.25 =$
$174{,}000$ in. lb

Moment due to gust:

$171{,}000 \times 1.25 = 214{,}000$ in. lb

Net moment = 40,000 in. lb

$t = 0.032$ in. $T = 860°$ F (at Sta 167) $I = \pi r^3 t = 340 \text{ in}^4$

This thickness is minimum due to aerodynamic heating.

$A = \pi dt = 3.0 \text{ in}^2$

$$\sigma = \frac{20{,}000 \times 1.25}{3.0} + \frac{40{,}000 \times 15}{340} = 10{,}110 \text{ psi}$$

$$\sigma_{buckling} = 9 \times 25 \times 10^6 \left(\frac{.032}{15}\right)^{1.6} = 11{,}200 \text{ psi}$$

No longitudinal stiffners needed

An internal pressure is required for panel flutter prevention. If 5 psi is used, the 10,110 stress would be reduced, accordingly.

WEIGHT AND BALANCE

SYSTEM TEST VEHICLE SECOND STAGE

ITEMS	WEIGHT
Structure	233
Propellant Tank Assembly	120
Guidance & Attitude Control	150
Propulsion System	160
Pressurization System	17
Destruct System	10
WEIGHT EMPTY	690
C. G. @ Sta.	(109)
PAYLOAD	
Telemetering	80
Power Source	223
Propellant	577
TOTAL PAYLOAD	880
C. G. @ Sta.	(101)
GROSS WEIGHT	1,570
C. G. @ Sta.	(105)

BOOSTER FIRST STAGE

Structure	370
Fins (4)	200
Misc.	40
Bottle - Loaded - (Sergeant)	8,270
BOOSTER - GROSS WEIGHT	8,880
C. G. @ Sta.	(292)

COMBINATION

Vehicle - Gross Weight	1,570
Booster - Gross Weight	8,880
GROSS WEIGHT - COMBINATION	10,450
C. G. @ Sta.	268
Expend Booster Propellant	- 7,100
COMBINATION - BOOSTER PROPELLANT EXPENDED	3,350
C. G. @ Sta.	227

NOTE: All C. G. locations are referenced to the extreme tip of the System Test Vehicle which is Sta. 0.

I-APPENDIX

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